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SUBJECT: Spatial Orientation of a CSM Relative to a Sun-Oriented SWS during a Typical AAP Rendezvous - Case 610

DATE: September 30, 1969

FROM: C. O. Guffee
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MEMORANDUM FOR FILE

I. Introduction

This memorandum describes a study of the motion of the SWS-CSM line-of-sight relative to a sun-oriented SWS during the coelliptic-orbit and the terminal-phase portions of an AAP rendezvous. This study provides information that can be used to determine the required location and antenna characteristics of VHF ranging transponders on the SWS for use during the CSM rendezvous. The data can also be used to determine the visual aspect of the SWS as seen from the CSM during the final portions of the rendezvous.

II. Discussion

The present baseline requires the SWS to be in a sun-oriented, inertially fixed attitude throughout the mission, including the rendezvous portion. This attitude has the -z body axis directed towards the sun, and the x body axis in the orbital plane. For this study, the inertial attitude was chosen so that the +y body axis is above (north of) the orbital plane. Figure 1 illustrates the SWS body axis system.

In general, the AAP rendezvous will be ground controlled up to Terminal Phase Initiation (TPI), with the CSM computer providing the navigation and guidance capability for the terminal phase portion of the rendezvous. Thus the optical tracking of the SWS from the CSM and VHF ranging are crucial to the successful accomplishment of the rendezvous terminal phase. However, since the trajectory of the CSM under ground control can vary considerably prior to the rendezvous terminal phase, depending on the relative position of the CSM with respect to the SWS at insertion, the study was restricted to the portion of the rendezvous trajectory following the coelliptic maneuver when the optical tracking and VHF ranging are most important. Conversations with MSC mission planning personnel indicate that there should be between thirty and sixty minutes spent in coelliptic orbit prior to TPI. The minimum time allows sufficient tracking and navigation to prepare for the TPI maneuver, while the maximum time is imposed to prevent excessive buildup of errors from the coelliptic maneuver. Therefore, this study considered the mission beginning about 4000 seconds prior to TPI.

The SWS was assumed to be in a 220 nautical mile circular orbit at an inclination of 35 degrees; a coelliptic orbit 10 nautical miles below the SWS was used. TPI was initiated when the line-of-sight vector from the CSM to the SWS was 28 degrees above the CSM local horizontal, and there was a 140 degree transfer angle of the SWS from TPI to intercept.

Since intercept or TPF occurs at the dawn terminator, the attitude of the solar-oriented SWS could be determined at any time by working back from the TPF.

The position of the sun with respect to the orbit plane is given by beta: the angle from the orbit plane to the earth-sun vector. This angle is measured in the plane that contains the sun vector and the normal to the orbital plane, and is positive when the sun is about (north of) the orbital plane. For a 35-degree inclination orbit, the beta angle can vary over a range of ± 58.5 degrees. This memorandum presents data for beta angles of 0, +50 and -50 degrees, which will indicate the general transponder coverage required during the final phases of a sun-oriented SWS rendezvous for any CSM launch time.

III. Results

The final portions of the rendezvous were simulated with the SWS attitude inertially fixed according to the given value of beta. The instantaneous inertial line-of-sight vector from the SWS to the CSM was determined at various points through out the mission and transformed to SWS body axes.

Since the SWS has an inertially fixed attitude, the line-of-sight vector expressed in SWS body axes sweeps out a planar arc. This plane includes the body x axis, and is inclined with respect to the body +z axis by the angle beta. The arc includes an angle of about 270 degrees during the portion of rendezvous considered. Figure 2 shows a polar plot of CSM position in SWS body axis for beta equal to zero. Figure 3 is a polar plot for beta equal to ± 50 degrees.

The rendezvous targeting is based on TPF occurring at the dawn terminator or intersection of the earth's shadow and the orbit plane. Since the SWS orbit is above the earth's surface, the terminator position moves further away from orbital noon as the magnitude of beta increases from zero. Therefore, the relative attitude of the SWS (with respect to the CSM) during the various rendezvous phases will be a function of beta. There is a shift of about 10 degrees as beta varies from 0°-50°

in the aspect of the CSM as viewed from the SWS. This is illustrated in Figures 2 and 3 where each arc covers about 270 degrees; but are shifted with respect to each other. Therefore to insure transponder coverage over the total range of beta, 280 degree coverage must be provided.

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R. C. Purkey

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Attachments

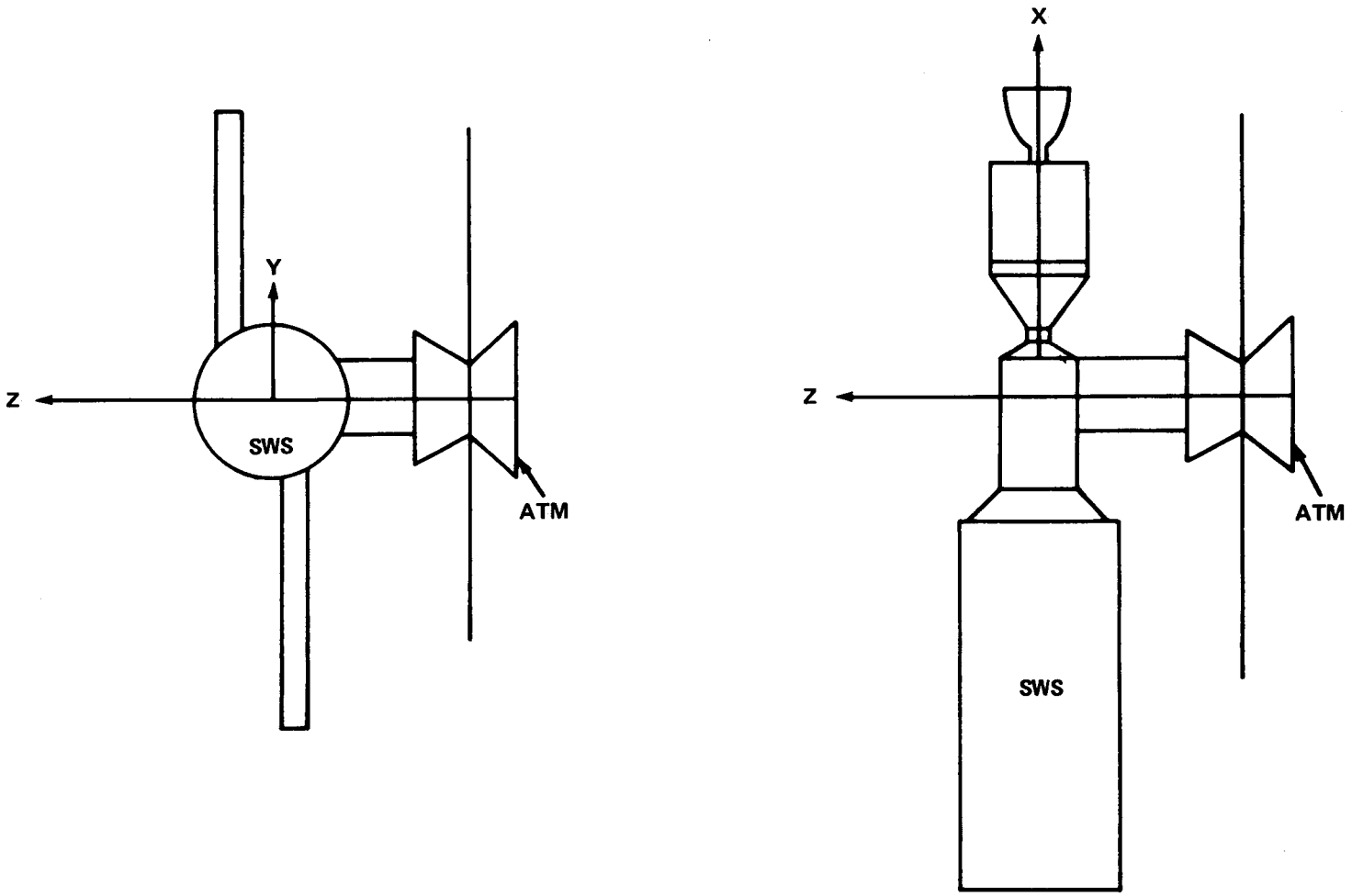

FIGURE 1: BODY AXES OF SWS

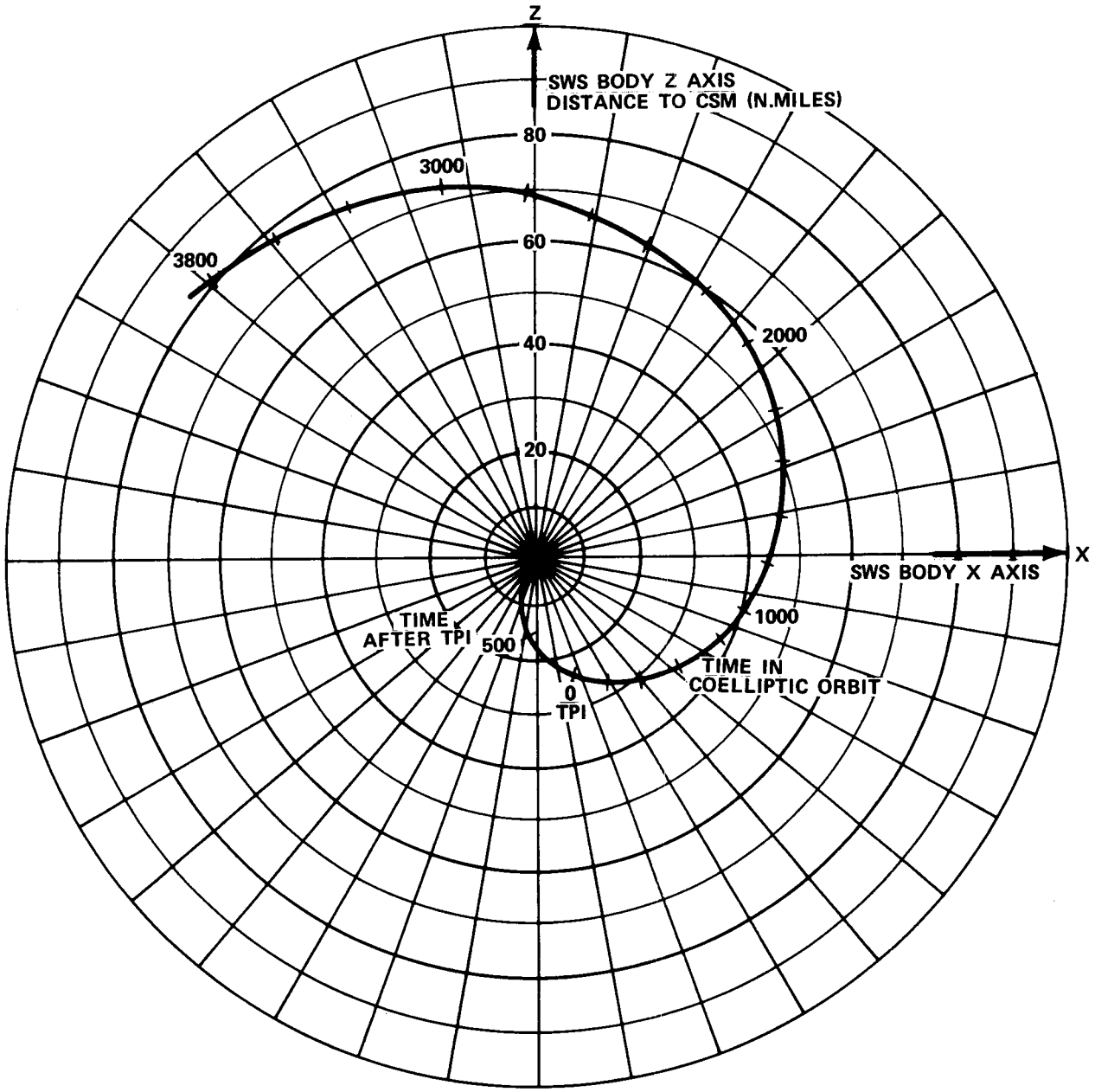

FIGURE 2: CSM POSITION AND DISTANCE EXPRESSED IN SWS BODY AXES
FOR BETA = 0^{o}

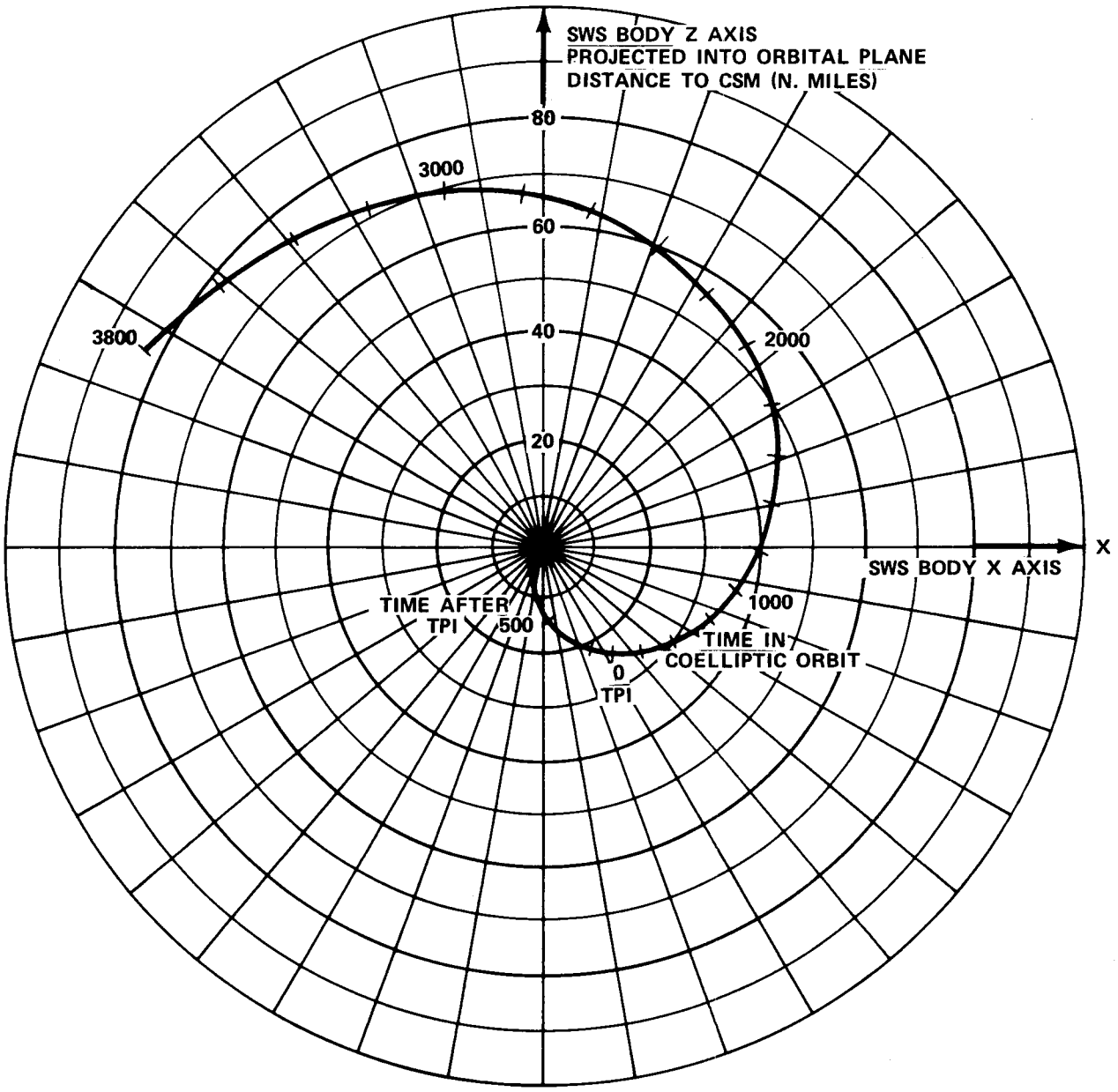

FIGURE 3: CSM POSITION AND DISTANCE IN ORBITAL PLANE FOR BETA = $\pm 50^{o}$

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